Ocean Surface Salinity from Aircraft Microwave Radiometer and Radar Measurements

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Sea surface salinity (SSS) is a key parameter for studying ocean circulations and global hydrologic budgets. Recent studies have shown that assimilating SSS combined with other parameters has a positive impact on coupled forecasts. In addition, the ocean rainfall is reflected in the SSS variability, enabling estimates of ocean rainfall from SSS to balance surface freshwater flux in the climate prediction models. The ocean surface salinity has been viewed as a missing element in satellite ocean observations.

The principles of satellite SSS remote sensing are based on the sensitivity of sea surface brightness temperatures (Tb) to SSS. The sea surface Tb is a function of the water dielectric constant and surface temperature (SST). The water dielectric constant, influencing the electromagnetic reflectivity of sea surfaces, is a function of salinity, temperature, and radio frequencies. The 1.4 GHz (L-band) frequency band set aside for radio astronomy use is considered to be adequate for SSS remote sensing. To investigate the feasibility of SSS remote sensing with an accuracy of 0.2-0.3 psu required for weekly global mapping of open oceans, the aircraft Passive Active L/S (PALS) microwave instrument has been developed by the Jet Propulsion Laboratory (JPL). This instrument is a dual-frequency, dual-polarized combined radiometer and radar. This instrument has been flown on the NCAR C-130 with three flights off US east coast across the Gulf Stream and National Data Buoy Center (NDBC) buoys on July 17-19, 1999. The in-situ sea surface salinity was provided by the Cape Hatteras research vessel from Duke University.

It has been recognized that the surface roughness is a crucial error source for SSS retrieval from microwave observations. The PALS dataset has been analyzed to quantify the influence of surface roughness. The data indicate that the excess brightness temperatures due to sea surface roughness can be as high as 1 to 2 Kelvins, which will yield about 2-3 psu SSS errors if uncorrected. The PALS data suggest a linear relationship between the excess brightness temperatures and the radar measurements for the range of wind speed encountered wind (<7 m/s). A linear relationship is consistent with the Bragg scattering theory for sea surfaces, which predicts a linear dependence of the excess brightness temperatures and radar backscatter on the surface wave spectra. The proportional coefficients, estimated from the PALS data, vary with the polarization and frequency. We remove the excess brightness temperatures from the PALS radiometer data with this linear model. The standard deviation of the residual errors is estimated to be less than 0.2 Kelvin. By comparison with the Cape Hatteras SSS data, the SSS retrieval error approaches the accuracy required for open ocean conditions.